Development of New Tools in Biometrics Research

The Biometrics Research Unit of the New York State Department of Mental Hygiene has undertaken the task of providing objective measures for assessing the characteristics and behavior of mental patients. To this end, a variety of techniques have been developed for assessing premorbid and morbid characteristics and behavior, behavior and its alterations during the course of the illness, and on followup. The premorbid characteristics are tapped by interviewing methods; the morbid status, by standardized mental status interviews and observational techniques as well as by psychological test performance. The course of illness is evaluated by means of ward behavior inventories and outcome on followup by special inventories built for this purpose.

In the area of psychological test performances we have developed techniques for sampling the physiological, sensory, perceptual, psychomotor and conceptual responses of the individual. In this paper a description is given of one of the physiological measures—pupillography.

In the area of observational techniques, we present a description of several of our tools: Ward Behavior Rating Scales; Mental Status Schedule and Inventory; The Structured Clinical Interview and Inventory; and the Children's Behavior Inventory.

Instrumentation for Research in Pupillography*

Over the centuries, scientists and physicians have been interested in the fact that the opening of the iris becomes smaller when light is directed on the eye. This contraction of the pupil and the subsequent redilation have been recognized as complicated reflexes and have been the subject of a great number of studies in a variety of fields. Physiologists and anatomists have extensively explored the structure of the iris muscles and the neural pathways and nuclei which play a role in controlling the course of the pupillary contraction and dilation (Loewenfeld, 1958; Poljak, 1957). More recently, the pupillary reaction has been studied as an example of a biological servo mechanism (Stark, 1959). Attempts have been made to derive mathematical equations which would describe pupillary reaction to stimuli of known characteristics (Clynes, 1959).

The relationship between the pupillomotor and psychophysical responses to visual stimulation has been of great interest to those concerned with the study of visual function (DeGroot and Gebhard, 1952).

A number of studies in the literature are related to the usefulness of the pupillary reflex in both neurological and psychiatric diagnosis. Recently, Lowenstein and Loewenfeld produced a film to aid clinicians in the use of the pupillary reflex in the diagnoses of neurological disorders. In the area of psychiatric illness, one of the pioneer experimental studies was also done by Lowenstein together with Westphal in 1933. In our own laboratory we have done some work on this subject. We found, for example, that acute schizophrenic patients have a significantly

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smaller pupil than both chronic schizophrenics and controls, while there was no difference between chronic schizophrenics and normal controls.

When the new psychotomimetic and psychotropic drugs came into use, we and others observed that several of these drugs affect pupillary size and pupillary response (Carlson, 1957; Freeman, 1958; Dureman, 1959; Eysenck, 1960). Carlson reported that LSD and chlorpromazine have opposite effects on pupillary diameter. LSD enlarges the pupil while chlorpromazine produces a smaller pupil. Freeman found that both schizophrenics and normals show an increase in pupillary diameter after the ingestion of LSD. Eysenck reported an increase in pupil diameter due to ingestion of meprobamate.

In our own work with these drugs we have observed a considerable increase in pupillary diameter about 3 hours after the intake of psychomimetic drugs (Mescaline, LSD, psilocine), together with a decrease in the pupillary contraction to a light flash. We found little or no change in the pupill diameter of the dark-adapted eye in subjects who had ingested a small dose of chlorpromazine. There was, however, a decrease in the speed and extent of the redilation after cessation of light stimuli.

Attempts to develop an objective recording method date back to Bellarminoff in 1888. He used a method of photographing the eye through a narrow slit and obtained thereby a continuous record of the largest pupillary diameter. Since that time, a number of devices have been built and used with varying degrees of success. Until recently, progress in this field went hand in hand with improvements in infrared sensitive film. Lowenstein (1956) developed a method of infrared cinography which proved to be quite satisfactory. Usually 10 pictures are taken per second. The film is then developed and projected on a screen. The diameter of the enlarged image of the pupil is measured and transferred to graph paper. Since 10 frames are taken per second, the time resolution of the resulting "pupilograms" is somewhat limited. Although this method is quite accurate and reliable, it is rather tedious and time consuming. Therefore, attempts have been made to develop methods by which the pupillary diameter could be measured and recorded directly.

There are several possible solutions to this problem. Based on the work by Cuepper and others, Stark is using an apparatus which records the amount of infrared light reflected from the iris pigment. This reflected energy is inversely proportional to pupillary diameter. Since the amount of light reflected from the iris is dependent on the pigmentation of the eye, no absolute measurement can be obtained and a calibration curve is needed for each individual subject. Several other solutions are under consideration in Dr. Stark's laboratory, the most promising of which is a closed circuit television system.

The most advanced device at the present time is, however, the instrument developed by Lowenstein and Loewenfeld in collaboration with the General Precision Laboratory of Pleasantville, New York. A detailed description of this "electronic pupillograph" has been given by Lowenstein and Loewenfeld (1958) and by King (1960).

In our own work we have used the cinéphotography method of Lowenstein. We have also used an adaptation of the slit photography method, first described by Bellarminoff.

We are, at present, installing a system which will measure pupillary diameter directly and process the obtained information on line. This system consists essentially of three units.

1. Measuring apparatus.
2. Data storage and retrieving device.
3. Averaging computer.

We use the Lowenstein "Electronic Pupillograph" as our basic measuring instrument. This instrument uses a mechanically controlled spot of infrared light to scan a 1½" wide, by 3½" area with a 12-line 60 cps raster. A system of lenses and beamsplitters projects the image of this raster on the irises of both eyes. The infrared light is not visible to the subject. A portion of the light beam reflected from the subject's eye is picked up by a lens system and absorbed by the sensitive surface of a photomultiplier. The output signal of the photomultiplier is amplified, clipped, and
fed into a processor. One scanning line of the 12-line raster will correspond closely to the pupil at its largest horizontal diameter. This “largest diameter scan” is used to generate a voltage which in turn drives a Texas Instrument “Recti-Riter” penwriter. Range selectors allow for recording of a specific range of pupillary diameter, i.e., the total width of the recording paper (4 1/2”) can be used to represent any 2mm range of pupillary diameter. This allows the detection of very small changes in pupillary diameter.

A bite board made of Kerr dental compound is prepared for each subject and fixed in a head rest device in front of the instrument. This allows the subject to leave the apparatus during the rest period in the experiments and return to exactly the same focussed position.

The instrument allows for measurement of both pupils at the same time. A comparison circuit computes differences between the two pupils, so that static and dynamic anisocoria can be detected. The position of both eyes, as well as the signals obtained from the reflection of the infrared light can be monitored on two 3-inch cathode ray tubes. Small eye movements do not interfere significantly with the accuracy of pupillary measurements.

For precise study of subtle changes in pupillary response it is imperative to reduce the interference of “biological noise” with the response being studied. This “noise” is probably the resultant of the influence of the numerous centers in the brain which act directly or indirectly on the two muscle groups which determine pupillary diameter. In any single recording, a small response of the pupil, e.g., the response of the pupil to light of threshold intensity, is often buried in larger diameter fluctuations. By analogy with work on evoked potentials, average response techniques can be used to bring out responses which are smaller in magnitude than the noise. We have found that by averaging the responses to 50 repetitions of the same experimental condition, pupillary responses of the order of .05 mm can be easily detected.

Since for 1 second of record a minimum of 10 averages must be obtained, the procedure is very time consuming and the results of an experimental session are available for evaluation only after several weeks. It is, therefore, desirable to use an electronic computer which will provide on-line averaging. Computed data can then be inspected at the end of the experiment. One computer which can be readily adapted to this purpose, and whose input requirements are compatible with the Electronic Pupillograph, is the Mnemeton Computer of Average Transients (CAT). The recent model allows computation on four separate data channels. The average response curve is displayed on an oscilloscope and can be permanently recorded on a strip chart recorder.

The usefulness of such a system can be greatly extended by interposing a magnetic tape data storage between the Pupillograph and the computer. For this purpose we are using the Mnemeton seven channel Ampex system. Such a storage device permits the identification and coding of different categories of data and can be used for the separate processing of data which have been coded as to stimulus parameter or other experimental conditions. Of particular interest is the case where the basis for selection is the report of the subject (“seen” or “not seen,” “bright,” “dim,” etc.) which is only available after the pupillary response has been obtained. Trials which have to be rejected because, for example, of the presence of eye blinks at critical moments in the experiment, can be eliminated from the averaging by this method. An automatic tape search system for rapid recovery of the data so identified is being developed in our laboratory.

The total system described above will enable us to have the results of our experiments completely analyzed and ready for interpretation shortly after termination of the experimental session. We, thereby, expect to increase the scope and volume of our experiments, and free ourselves from the frustration of having to wait several weeks for the results of an experiment.

Although not directly a part of the recording and processing system several comments might be added on the light stimulus control for pupillary work. The Electronic Pupillograph is equipped with a light source (Sylvania glow modulator tube R 1131-C) which
can be directed to either eye of the subject. Under conditions of darkness the normal pupillary response is consensual and there is generally no need for a second light source. Intensity of the light stimulus is controlled by the insertion of neutral density filters. The Electronic Pupillograph, however, has only limited provisions for the control of stimulus duration and interstimulus interval. We have found it necessary to add electronic timers of our own design which program and control duration of the light stimulus, dark-adaptation, and other events during the experiment.

In working with untrained subjects, eye movements present a serious problem in the control of the effective light energy reaching the retina. To circumvent this problem, we have used in most of our experiments a monocular "Ganzfeld" light source. A light is directed on the convex side of a 1½" ground glass hemisphere (we use half a ping pong ball for this purpose). The concave side of the hemisphere is positioned over the subject's left eye. The light is dispersed in such a way that the total visual field of the subject's left eye is evenly illuminated. The same amount of light will then always enter the subject's eye, even if he does not fixate properly or moves his eyes. The effective retinal illumination in Troland can be computed by considering the pupillary diameter at the time of stimulation.

References
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Observational Inventories for the Assessment of Mental Patients*

A program of research on methods for the quantitative evaluation of mental patients has been underway for several years at the Biometrics Research unit of the New York State Department of Mental Hygiene, with support from NIMH Grant M-3546. The program has focused on the development of observational inventories and structured interviews. Considerable attention has been devoted to determining appropriate statistical models for assessing reliability. The overall aim of this research is measurement of severity of illness, of course of illness (i.e.,

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